HEATER DRIVE CIRCUIT

BACKGROUND OF THE INVENTION

Field of the Invention

5   The present invention relates to a heater drive circuit for driving a fixing heater used for a laser beam printer and an electrophotographic copying machine.

Related Background Art

10   A glass tube heater in which a glass tube is filled with a gas and an exothermic conductor is heated in this gas environment, has hitherto been often used as a heating means of a fixing heater utilized for a laser beam printer and an

15   electrophotographic copying machine. In particular, a so-called halogen heater involving the use of a halogen gas as the above gas is widely utilized. This glass tube heater functions electrically as a non-linear device and has such a characteristic that

20   an electric resistance is low in a state where a temperature of the heater is low and rises when the heater is heated. This characteristic leads to an increase in rush current when heater is switched ON/OFF.

25   Generally, TRIAC defined as an AC (Alternate Current) ON/OFF device is broadly utilized as a device for driving the heater. A thermistor for

detecting a temperature is attached to a fixing unit, and a device for controlling the fixing unit switches ON/OFF the TRIAC in a way that detects a temperature of the thermistor. None of problems arise while the

5   heater is kept heated, however, if switched ON in state where the heater is cooled, an excessive current flows to the heater and the TRIAC due to the non-linear characteristic of the heater. Incidentally, the rush current of the heater reaches

10   a level that is approximately ten times as much as the current in a steady state.

     The rush current at the heater ON-time naturally flows also to an AC power supply line, wherein an instantaneous voltage drop is caused by

15   the rush current due to impedance of the AC line, with the result that a so-called flicker occurs. The flicker means a flicker of interior lighting equipment due to the instantaneous voltage drop of the AC line. The flicker uncomfortably affects a

20   feeling of a user. Especially, the high-speed laser beam printer and the electrophotographic copying machine requires a high-power heater, and there must be a large influence by this flicker.

     For coping with this problem arising from the

25   flicker, as disclosed in, e.g., Japanese Patent Application Laid-Open No. H6-230702, not the low-frequency ON/OFF control by the TRIAC but the high-

frequency switching control is adopted. A Field
Effect Transistor (FET) is employed as a device for
this switching control, and a LC filter circuit is
utilized for an output of the switching circuit in
5   order to restrain copy noises.

     The switching device such as the FET switches
ON/OFF only the current in one direction at a high
frequency, and therefore requires a circuit for full-
wave-rectifying an AC line voltage. Namely, an AC
10   sine wave pattern is converted into a full-wave-
rectified voltage wave pattern, the full-wave-
rectified voltage wave pattern is further subjected
to switching by the FET, then the wave pattern
thereof is corrected by the LC filter, and the wave-
15   pattern-corrected voltage is supplied to the heater.
The FET as the switching device, though ON/OFF-
controlled at the high frequency, adjusts a peak
value or an average value of the voltage wave pattern
applied to the heater. Namely, the FET keeps the
20   voltage supplied to the heater to a predetermined
value. Then, when the heater is switched ON/OFF, a
duty cycle ratio thereof is so controlled as to
gradually increase from a low value. The control of
the duty cycle at the ON/OFF time is called slow-up
25   control. Under this slow-up control, the peak value
or the average value of the full-wave-rectified
voltage applied to the heater when switched ON/OFF

rises stepwise, and hence there is no excessive flow of the rush current at the ON/OFF time.

Thus, the rush current can be restrained low by performing the ON/OFF control of the switching device operating at the high frequency, thereby obviating the flicker problem.

The laser beam printer and the electrophotographic copying machine are, however, accompanied with a difficulty other than the flicker in order to control the electric power for the heater. This is a restriction of the maximum electric power.

In Japan, the AC line voltage is nominally 100 V (an effective value) for the general interior wiring, and the maximum current per receptacle is determined to be 15 A. Accordingly, in the 100 V wiring, only the electric power of 1,500W at the maximum can be supplied. Further, in North America, the AC line voltage is nominally 120 V (the effective value), and the maximum current per receptacle is determined to be 13.2 A. Therefore, in the 120 V wiring, only the electric power of 1,584 W at the maximum can be supplied. In EU, the AC line voltage is nominally 230 V, and the maximum current per receptacle is 10 A. Hence, the electric power up to 2,300W can be supplied.

On the other hand, in the high-speed laser beam printer and electrophotographic copying machine

(capable of printing, e.g., 50 sheets per minute),
the electric power needed for the heater is as high
as 1,000W. The heater consumes the electric power as
much as 1,000W of the total electric power of 1,500W.

5   Consequently, all the control of the apparatus must
be done by the remaining electric power of 500W.
Moreover, the heater drive circuit has a drive loss,
and therefore the electric power utilizable for other
than a heater system becomes much less. Still

10   further, the high-speed electrophotographic copying
machine involves the use of a glass tube lamp for
scanning an image of an original, and a large amount
of electric power is consumed for this glass tube
lamp. Furthermore, in the high-speed laser beam

15   printer and electrophotographic copying machine, a
sheet feeding device and a sheet discharging device
(a stacker and a stapler) as options are utilized
often together, and hence it is more difficult to
restrain the electric power down to totally 1,500W or

20   under. As a matter of fact, however, power supply
lines of approximately 200 V, though existing in
Japan and North America, are not widely utilized.
Therefore, the apparatuses operable at 100 V and 120
V gain high popularity.

25   Another problem is that the electric power
consumed by the heater has a large dispersion. The
electric power consumed by the glass tube heater such

as a halogen heater has a large dispersion (which is normally on the order or ±3.5%) depending on lots. Taking this dispersion into account, the electric power must be restrained down to totally 1,500W or under in Japan. In a case where a resistance value of the heater is low and the electric power consumed rises, if contrived to meet this specified electric power of 1,500W, it follows that there occurs a 7% decrease at the maximum in the electric power for consumption on such an occasion that the heater resistance value rises and the electric power consumed by the heater is lowered. For example, assuming a fixing unit requiring 1,000W in a way that takes the heater-related power dispersion into consideration, it follows that the electric power consumed by the heater comes to 1,070W at the maximum due to a dispersion of the resistance value of the heater. As a result, there occurs a 70W reduction in the amount of electric power utilizable for other than the heater.

As described above, under circumstances of the power supply voltages in Japan and North America and due to the dispersion in the electric power for the glass tube heater, the high-speed laser beam printer and electrophotographic copying machine have a difficulty to attain the restriction of the maximum electric power. In fact, in Japan and North America,

the high-speed machine capable of printing
approximately 80 sheets per minute has no alternative
but to utilize the 200V power supply.

Accordingly, the high-speed laser beam printer
5   and electrophotographic copying machine is incapable
of further improving the printing speed because of
the restriction of the total amount of utilizable
electric power.

10   SUMMARY OF THE INVENTION

It is an object of the present invention to
provide a heater drive circuit capable of improving a
printing speed of an image forming apparatus to the
greatest possible degree under such a condition that
15   a total amount of utilizable electric power is
restricted in the image forming apparatus including a
fixing heater (a heating heater).

To accomplish the above object, a heater drive
circuit according to the present invention comprises
20   current detecting means for detecting a value of a
current across an AC power supply line that is
supplied from a commercial AC power supply, full-wave
rectifying means for full-wave-rectifying an AC
voltage on the AC power supply line, switching
25   control means for performing switching control of the
full-wave-rectified voltage from the full-wave-
rectifying means at a high frequency, filter means

for removing a high frequency component contained in a switching output from the switching control means, a heating heater receiving an application of an output from the filter means, and heater control

5   means for ON/OFF-controlling the switching control means on the basis of the current value detected by the current detecting means.

According to the present invention, even if a resistance value of the heating heater has a

10 dispersion, the heating heater can be supplied with the stable electric power, and hence the electric power supplied to the heating heater can be increased to the limit of the standard value of the current of the AC power supply line, whereby the heater drive

15 circuit can be utilized as a high-output heater drive circuit.

Preferably, the current detecting means is constructed of a current transformer interposed in series in the AC power supply line and a

20 rectification circuit connected to an output winding of the current transformer.

Preferably, the switching means includes a switching transistor and a current retaining diode connected to the switching transistor, and changes an

25 ON/OFF duty of the switching transistor.

Preferably, the heater control means gradually increases the ON/OFF duty when starting the drive of

the heater as set ON from OFF, and controls the
ON/OFF duty so that the current value detected by the
current detecting means is held to a predetermined
value at a point of time when predetermined or longer
5   time elapses since the start of the operation.

Another heater drive circuit according to the
present invention comprises current detecting means
for detecting a value of a current across an AC power
supply line that is supplied from a commercial AC
10   power supply, full-wave rectifying means for full-
wave-rectifying an AC voltage on the AC power supply
line, switching control means for performing
switching control of the full-wave-rectified voltage
from the full-wave-rectifying means at a high
15   frequency, filter means for removing a high frequency
component contained in a switching output from the
switching control means, a heating heater receiving
an application of an output from the filter means,
voltage detecting means for detecting a voltage
20   applied to the heating heater, and heater control
means for ON/OFF-controlling the switching control
means on the basis of the current value detected by
the current detecting means and the voltage value
detected by the voltage detecting means.

25   Preferably, the voltage detecting means detects
any one of an average value and a peak value of the
voltage applied to the heating heater.

Preferably, the current detecting means is constructed of a current transformer interposed in series in the AC power supply line and a rectification circuit connected to an output winding

5   of the current transformer.

Preferably, the switching control means includes a switching transistor and a current retaining diode connected to the switching transistor, and changes an ON/OFF duty of the switching

10 transistor.

Preferably, the heater control means gradually increases the ON/OFF duty when starting the drive of the heater as set ON from OFF, and controls the ON/OFF duty so that the current value detected by the

15 current detecting means is held to a predetermined value at a point of time when predetermined or longer time elapses since the start of the operation.

Preferably, the heater drive circuit further comprises storage means for storing the voltage value

20 detected by the voltage detecting means when controlling the ON/OFF duty of the switching control means so that the current value detected by the current detecting means comes to a predetermined value in a state where the voltage value on the AC

25 power supply line is fixed to a predetermined value, wherein the switching control means, when a predetermined condition is met, controls the ON/OFF

duty so that the voltage value detected by the voltage detecting means is equalized to the voltage value stored on the storage means or to a value corresponding to the voltage value.

5   With this contrivance, even when the voltage of the AC power supply line fluctuates in addition to the dispersion in the resistance value of the heating heater, the electric power supplied to the heating heater can be stabilized. It is therefore possible
10   to increase the electric power supplied to the heating heater to the limit of the standard value of the current of the AC power supply line, whereby the heater drive circuit can be utilized as a high-output heater drive circuit.

15   Preferably, the predetermined condition is a condition that the heater drive circuit be utilized by a general user.

BRIEF DESCRIPTION OF THE DRAWINGS

20   FIG. 1 is an electric circuit diagram showing a configuration of a heater drive circuit in a first embodiment of the present invention;

      FIG. 2 is a diagram showing detailed circuitry of a rectification circuit in FIG. 1;

25   FIG. 3 is a diagram showing detailed circuitry of a voltage detecting circuit in FIG. 1;

      FIG. 4 is a diagram showing detailed circuitry

of a heater control circuit in FIG. 1;

FIG. 5 is a diagram showing a voltage wave pattern after being rectified and a heater drive voltage wave pattern at a normal time;

FIG. 6 is a graph showing one example of input/output voltage transfer characteristics of the voltage detecting circuit in FIG. 3;

FIG. 7 is a flowchart showing procedures of a main routine executed by a micro controller in FIG. 4;

FIG. 8 is a flowchart showing in-depth procedures of a heater voltage adjustment processing subroutine in step S11 in FIG. 7;

FIG. 9 is a diagram showing one example of a voltage wave pattern applied to the heater when in a heater slow-up sequence;

FIG. 10 is a flowchart showing procedures of a main routine executed by the micro controller for a heater control circuit contained in the heater drive circuit in the first embodiment of the present invention;

FIG. 11 is a flowchart showing detailed procedures of a heater resistance value measurement processing subroutine in step S36 in FIG. 10; and

FIG. 12 is a flowchart showing in-depth procedures of a heater voltage adjustment processing subroutine in step S39 in FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

5   FIG. 1 is an electric circuit diagram showing a configuration of a heater drive circuit in a first embodiment of the present invention.

In FIG. 1, a rectification circuit 114 converts an AC voltage into a DC voltage, a heater control

10   circuit 115 controls switching of a heater 112, and a voltage detecting circuit 116 detects a peak value or an average value of full-wave rectification voltage wave patterns applied to the heater 112.

FIG. 2 is a diagram showing detailed circuitry

15   of the rectification circuit 114. FIG. 3 is a diagram showing detailed circuitry of the voltage detecting circuit 116. FIG. 4 is a diagram showing detailed circuitry of the heater control circuit 115.

Note that DC—DC converters 118 and 119 are

20   shown in the block diagram, however, the detailed circuitry thereof is not illustrated. This is because these DC-DC converters 118 and 119 are normally often used. The DC-DC converters 118 and 119 control output voltages to desired voltage values,

25   respectively. Further, in each of interiors of the DC—DC converters 118 and 119, a primary-side input and a secondary-side input are electrically separated.

Namely, a transmission of electric power from the primary side to the secondary side involves the use of a switching transformer. Moreover, a signal is transmitted by a photo coupler to the primary side from the secondary side in order to stabilize the voltage on the secondary side.

Further, a printer controller 104 is shown in the block diagram but does not characterizes the present invention, and hence its detailed circuitry is not illustrated.

Referring to FIG. 1, an AC power supply 101 is commercial electric power supplied from outside and is, if in Japan, AC 100V.

An AC line filter 102 serves to prevent switching noises caused by the heater drive circuit in the first embodiment from being transferred to an outside AC line. The AC line filter 102 is constructed of a common mode choke and a cross line condenser as utilized by a normal electric appliance. These components are not circuits characteristic of the present invention, and therefore their detailed circuitry is not illustrated.

An AC voltage outputted by the AC line filter 102 is inputted to a diode bridge 103. The diode bridge 103 serves to effect full-wave rectification of an AC voltage wave pattern. The diode bridge 103 is well known as a device for generating a DC (direct

current) voltage from an AC voltage, and is normally
constructed of four pieces of diodes. The diode
bridge 103 is the well-known device, and hence its
detailed explanation is omitted.

5   The current transformer 106 is connected in
series to the diode bridge 103. The biggest
different point of the current transformer 106 from a
normal voltage conversion transformer is that an
input impedance as viewed from the primary side is
10   extremely small. For obtaining this characteristic,
the number of turns of the primary-side windings is
minimized (which is normally one turn), and the
primary side and the secondary side are set in loose
coupling. As the primary-side input impedance of the
15   current transformer 106 is extremely small, a large
proportion of the AC voltage outputted by the AC line
filter 102 is applied to the diode bridge 103, and
almost none of the voltage is applied to an input
terminal of the current transformer 106.

20   An output-side winding of the current
transformer 106 is provided with three pieces of
terminals. A tap terminal in the middle thereof is
connected to the ground of the heater control circuit
115, and the terminals at both side ends thereof are
25   inputted to the rectification circuit 114. Since the
number of turns of the secondary-side windings of the
current transformer 106 is taken extremely large,

some amount of AC voltage is induced on the secondary
side of the current transformer 106, though only a
slight voltage is applied to the input terminal of
the current transformer 106. The voltage induced on

5   the secondary side is inputted a ~A terminal and a ~B
terminal of the rectification circuit 114. The
rectification circuit 114 performs the full-wave
rectification of the AC voltage wave pattern inputted,
and converts the AC voltage into a DC voltage by use

10   of a filter circuit thereof.

As shown in FIG. 2, the rectification circuit
114 is constructed of diodes 201, 202 for effecting
the full-wave rectification of the inputted AC
voltage wave pattern, and of the filter circuit

15   consisting of resistances 203, 204 and a capacitor
205.

Thus, the current transformer 106 and the
rectification circuit 114 cooperate to be capable of
detecting the AC current of the AC power supply.

20   Referring back to FIG. 1, a detection output
from the rectification circuit 114 is inputted to a
DI terminal of the heater control circuit 115.

Now, the voltage subjected to the full-wave
rectification in the diode bridge 103 undergoes a

25   voltage conversion by a switching converter. This
switching converter is constructed of inductors 105,
110, film capacitors 107, 111, a FET 108 and a diode

109. This switching converter is a so-called down-
converter from which to output such a wave pattern
that the full-wave-rectified voltage wave pattern is
reduced as shown in FIG. 5, wherein the peak value

5   (or the average value) of the full-wave-rectified
voltage pattern is decreased. Herein, the FET 108
functions as a switching device, and the diode 109 is
a diode for a flywheel. The inductor 110 and the
film capacitor 111 configure a filter circuit and are

10   devices indispensable for the down converter. The
inductor 105 and the film capacitor 107 function as a
filter of an input part of the down converter. This
LC filter hinders a high-frequency switching current
from flowing to the diode bridge 103 and to the

15   primary winding of the current transformer 106. An
on-time ratio at a switching cycle of this down
converter is called an ON duty ratio. The peak value
(or the average value) of the full-wave rectification
wave pattern applied to the heater 112, increases or

20   decreases in proportion to this ON duty ration.

     The heater control circuit 115 controls the ON
duty ratio on the basis of the signal received from
the rectification circuit 114 and the signal received
from the voltage detecting circuit 116, thereby

25   performing the switching control of the FET 108. The
voltage detecting circuit 116 outputs, to the heater
control circuit 115, a voltage proportional to the

peak value (or the average value) of the voltage
applied to the heater 112. Accordingly, the heater
control circuit 115 executes the switching control in
a way that detects the input AC current and the
5   voltage applied to the heater 112.

Circuits for supplying the DC power are, as a
matter of course, required for operating the heater
control circuit 115 and the voltage detecting circuit
116. The circuits for supplying the DC power are the
10   aforementioned DC-DC converters 118, 119. The AC
voltage wave pattern after the AC line filter 102 is
full-wave-rectified by the diode bridge 113. Then,
an electric field capacitor 117 converts this AC
voltage into a DC voltage containing somewhat a
15   ripple. The DC voltage containing the ripple is
inputted to the DC-DC converters 118, 119. The DC
converters 118, 119 output an object DC voltage
containing the small amount of ripple. The DC
voltage from the DC-DC converter 118 is used mainly
20   in the heater control circuit 115, while the DC
voltage from the DC-DC converter 119 is used as an
auxiliary power supply output in the voltage
detecting circuit 116.

Thus, a reason why the power supply circuit is
25   separated into the DC-Dc converters 118, 119 is that
a reference ground potential of the heater control
circuit 115 is different from that of the voltage

detecting circuit 116. Due to the difference reference ground potentials, as described above, the two pieces of DC-DC converters separated by the transformer are utilized.

5   Next, an operation of the voltage detecting circuit 116 will be explained with reference to FIG. 3.

Referring to FIG. 3, the power for operating the voltage detecting circuit 116 is supplied from an

10   auxiliary power supply terminal + and an auxiliary power supply terminal -, and these terminals are connected to the output of the DC-DC converter 119 shown in FIG. 1. The auxiliary power is inputted to a power supply terminal of an operational amplifier

15   (OP amp) 304.

In the voltage detecting circuit 116, an input detecting part and a voltage output part are electrically separated. A photo coupler 305 electrically separates the input detecting part and

20   the voltage output part. An input-side circuit part (the input detecting part) of the voltage detecting circuit 116 is constructed of a Zener diode 308, resistances 301, 302, 307, capacitors 303, 306, an OP amp 304, a photo diode 305 (an input portion of the

25   photo coupler 305), and a photo transistor 309B (an output portion of the photo coupler 305). An input-side voltage detecting circuit part consists of

elements such as the resistances 301, 302, the capacitor 303 and the Zener diode 308.

When a voltage equal to or higher than a breakdown voltage of the Zener diode 308 is inputted,

5   the current flows to the resistances 301, 302, and a terminal-to-terminal voltage of the resistance 302 is inputted to the OP amp 304. The capacitor 303 is a capacitor for averaging (extracting a low frequency component) the detection voltage. The OP amp 304

10 functions so that a voltage equal to the terminal-to-terminal voltage of the resistance 302 is applied to between the terminals of the resistance 307. Hence, the current flowing to a photo diode 305A becomes proportional to the terminal-to-terminal voltage of

15 the resistance 302.

Note that the capacitor 306 is provided for stabilizing the current flowing to the photo diode 305A.

When the photo diode 305A receives the inflow

20 of the current and emits the light, a current proportional to the current flowing to the photo diode 305A flows to a photo transistor 305B on the output side. The current flowing to the photo transistor 305B flows to a variable resistance 309,

25 and as a result a terminal-to-terminal voltage of the variable resistance 309 is outputted as a voltage VOUT.

Note that a collector terminal of the photo transistor 305B is connected to a power supply terminal VCC1 of the heater control circuit 115.

A contrivance that the resistance 309 is the variable resistance aims at correcting dispersion in the current of the photo diode 305B. Generally, a current transfer efficiency between the primary side and the secondary side in a photo coupler 305 has approximately a 2-fold dispersion depending on between lots, and therefore the dispersion in the current transfer efficiency is corrected by adjusting a resistance value of the variable resistance 309.

Thus, the voltage proportional to the terminal-to-terminal voltage of the resistance 302 is outputted as the voltage VOUT.

FIG. 6 is a graph showing one example of input/output voltage transfer characteristics of the voltage detecting circuit 116. In FIG. 6, the axis of abscissas represents an average value of the voltage applied to the heater 112, while the axis of ordinates represents an output voltage of the voltage detecting circuit 116. Herein, a voltage VTH is a voltage value determined from the breakdown voltage of the Zener diode 308.

Thus, a value proportional to the average value (or the peak value) of the voltage applied to the heater 112, can be detected as the voltage VOUT.

It is to be noted that the reason for using the Zener diode 308 lies in an intention that the control be conducted in the vicinity of a target value of the voltage applied to the heater 112.

5   Next, an operation of the heater control circuit 115 will be explained referring to FIG. 4.

A basic function of the heater control circuit 115 is to generate a pulse Width Modulation (PWM) for driving the FET 108 from pieces of information
10   (serving as information proportional to the AC current and to the average voltage applied to the heater) received from the rectification circuit 114 and from the voltage detecting circuit 116.

Referring to FIG. 4, a 1-chip micro-controller
15   (which will hereinafter be abbreviated to "MC") 401 serves as a core of the heater control circuit 115. An interior of the MC 401 is provided with a MC core 401a, a ROM 401b, a RAM 401c, an EEPROM (Electrically Erasable Programmable ROM) 401d, a peripheral unit
20   401e and so on. The MC 401 operates in synchronization with a main clock supplied from an oscillator 402.

An output voltage from the rectification circuit 114 is inputted to the DI terminal of the
25   heater control circuit 115. The voltage inputted to the DI terminal is inputted to an AD converter 403. The AD converter 403 effectuates an AD (Analog-to-

Digital) conversion of the inputted analog voltage into digital data (which have herein an 8-bit width), and input the digital data as data DIDATA (0…7) to the MC 401. Herein, a description of (0…7)

5   represents data having the 8-bit bus width.

The output voltage from the voltage detecting circuit 116 is inputted to a DV terminal of the heater control circuit 115. A voltage of this DV terminal is inputted to an AD converter 404. The AD

10   converter 404 similarly performs the AD conversion, and the MC 401 is supplied with digital data DVDATA (0…7).

Thus, the MC 401 detects an AC input current (corresponding to the current flowing to the heater)

15   through the data DIDATA (0…7), and further detects an average value of the voltage applied to the heater 112 through the data DVDATA (0…7).

A timer counters 405 counts clocks supplied from the oscillator 407, and outputs a count value as

20   8-bit data TMRDATA (0…7) to a digital comparator 406. The timer counter 405 is defined as a so-called free-run timer, and is reset to OH at a next input clock when a timer count value reaches a maximum value (FFH). Therefore, the count value of the timer

25   counter 405 changes in a sawtooth wave pattern from OH to FFH at a predetermined cycle.

Note that the timer counter 405 has an

initialization terminal, whereby the timer counter
405 is initialized when a RST signal outputted from
the MC 401 becomes "TRUE" (e.g., HIGH LEVEL), and the
data TMRDATA (0...7) is reset to OH.

5   The digital comparator 406 receives an input of
the digital data PWMDATA (0...7) outputted from the MC
401 and an input of the digital data TMRDATA (0...7)
outputted from the timer counter 405, and compares
these two pieces of digital data. Then, when a value

10   of the data TMRDATA (0...7) is larger than a value of
the PWMDATA (0...7), the comparator 406 outputs HIGH
LEVEL.

Thus, the data PWMDATA (0...7) is converted by
the comparator 406 into a PWM pulse having a

15   predetermined cycle, and the PWM pulse is inputted to
a driver 408. Further, an output of the driver 408
is inputted as an output OUT of the heater control
circuit 115 to a gate of the FET 108.

Thus, the PWM pulse is applied to the FET 108.

20   Resistances 410, 411 and a photo coupler 409
form a circuit for receiving ON/OFF commands from an
exterior of the heater control circuit 115. The
exterior of the heater control circuit 115 implies a
printer controller 104 in FIG. 1. The photo coupler

25   409 is provided for attaining an electrical
separation in order to receive the commands from the
exterior. The ground of the heater control circuit

115 is connected to a source terminal of the FET 108. Namely, even the ground of the heater control circuit 115 has a large potential difference as compared with a box body of the control apparatus, and hence it is required that the printer controller 104 be electrically separated from the heater control circuit 115.

When the heater control circuit allows the current to flow toward an RET terminal from an FDRV terminal, the current is transferred via the photo coupler 409 and inputted as a FDRVO signal to the MC 401. The MC 401, upon receiving "TRUE" of the FDRVO signal, starts the heater control. Control processing thereof will hereinafter be explained.

FIG. 7 is a flowchart showing procedures of a main routine executed by the MC 401. FIG. 8 is a flowchart showing in-depth procedures of a heater voltage adjustment processing subroutine in step S11 of the main routine.

When the power supply is switched ON, the main routine in FIG. 7 is started up, wherein the MC 401 at first executes initialization processing in steps S1-S3. In step S1, a counter 1 stored on the memory (RAM 401c) within the MC 401 is reset to "0". In step S2, the data PWMDATA (0...7), which should be outputted to the digital comparator 406, is reset to "OH". Owing to this resetting, the value of the

data PWMDATA (0…7) inputted to the comparator 406
becomes "OH". In step S3, the MC 401 sets the RST
signal to "TRUE" (e.g., HIGH LEVEL) and initializes
the timer counter 405. The data TMRDATA (0…7)

5   outputted from the timer counter 405 is thereby reset
to "OH", and the output of the comparator 406 comes
to "0".

Thus, in the initial state, the FET 108 is set
in an OFF-state.

10   Next, in step S4, the MC 401 monitors the FDRVO
signal and continues to wait in step S4 till the
FDRVO signal becomes "TRUE" (e.g., LOW LEVEL). When
the printer controller 104 gives an instruction of
the operation of the heater, the current flows to the

15   FDRV terminal, and the FDRVO signal comes to the
"TRUE" state. When the MC 401 receives the FDRVO
signal of "TRUE", the processing proceeds to step S5,
wherein the RST signal is set in a "FALSE" state.
From this moment onwards, the timer counter 405

20   starts counting in synchronization with the clock
outputted by the oscillator 407.

Then, the MC 401 increments the counter 1 by 1
(step S6), and similarly increments the value of the
data PWMDATA (0…7) by 1 (step S7). At this time, the

25   value of the data PWMDATA increases by 1, and the
data value thereof is inputted to the digital
comparator 406.

Next, the MC 401, after waiting for
predetermined time T1 (step S8), moves to next step
S9. In step S9, the MC 401 judges whether or not the
value of the data DVDATA (0...7) is equal to or smaller

5   that a predetermined value VD1. If DVDATA (0...7) ≤
VD1, the MC 401 moves to step S10. Whereas if DVDATA
(0...7) > VD1, the MC 401 moves to step S11.

In step S10, the MC 401 judges whether or not
the value of the counter 1 reaches a value TMAX or

10   not. If the counter 1 ≠ TMAX, the MC 401 returns to
step S6. Whereas if the counter 1 = TMAX, the MC 401
moves to step S11.

The processing in steps S6 to S10 implies that
if the value of the data DVDATA (0...7) is equal to or

15   smaller than the value VD1, and for a period during
which the value of the counter 1 does not reach the
value TMAX, the value of the data PWMDATA (0...7) is to
be incremented. With this increment, the ON duty
ratio of the PWM pulse inputted to the FET 108

20   increases step by step from 0, thus increasing the ON
duty ratio of the FET 108 till the voltage applied to
the heater 112 reaches the predetermined value (till
the value of the data DVDATA (0...7) comes to the value
VD1). A series of processing described above

25   corresponds to a slow-up sequence of the heater 112.
If the slow-up sequence of the heater 112 is carried
out, the peak value of the full-wave rectification

wave pattern applied to the heater 112 gradually rises.

FIG. 9 conceptually illustrates this state. In FIG. 9, the peak value of the full-wave rectification wave pattern abruptly rises. In fact, however, this peak value is extremely slowly raised. The slow rise thereof may involve elongating the waiting time in step S8. What has been described so far is the slow-up sequence when switching the heater ON.

Step S11 is an execution of applied voltage adjustment processing of the heater 112 after the slow-up. As described above, the heater voltage adjustment processing in step S11 involves performing the control shown in FIG. 8.

Referring to FIG. 8, the MC 401, to begin with, reads the data DIDATA (0...7) a plural number of times and obtains an average value thereof. This average value is set afresh as data DIDATA (0...7).

Then, the MC 401 compares the value of the data DIDATA (0...7) with a preset value DTGT, and thus examines a relationship between their magnitudes (steps S22, S23). If DIDATA (0...7) > DTGT, the MC 401 moves to step S24, wherein the value of the data PWMDATA (0...7) is decremented by 1. If DIDATA (0...15) < DTGT, the MC 401 moves to step S25, wherein the value of the data PWMDATA (0...7) is incremented by 1. Further, if DIDATA (0...15) = DTGT, none of the data

PWMDATA (0...7) is changed.

Then, the MC 401 moves to processing in step S26 and, after waiting just for predetermined time T2, terminates the present heater voltage adjustment
5 processing.

Subsequently, returning to step S12 in FIG. 12, the MC 401 checks whether the FDRVO signal becomes "FALSE" or not. As far as the FDRVO signal is "TRUE", the MC 401 repeatedly executes the heater voltage
10 adjustment processing in step S11 many times. While on the other hand, when the FDRVO signal becomes "FALSE", the MC 401 moves back to first step S1, wherein the FET 108 is switched OFF.

Thus, the value of the data DIDATA (0...7) is
15 substantially equalized to the value DTGT. The value of the data DIDATA (0...7) is stabilized to the predetermined value, which means that the electric power supplied to the heater 12 is stabilized to the predetermined value. The reason why so is that
20 unless the AC power supply voltage 101 changes, the voltage inputted to the diode bridge 103 is kept to a desired value, and the current flowing to the diode bridge 103 is likewise kept to the predetermined value. Namely, supposing that the resistance value
25 of the heater 112 decreases due to the dispersion in the lots, the value of the data DIDATA (0...7) is to be maintained to a fixed value, the voltage applied to

the heater 112 somewhat decreases, and nevertheless the value of the current flowing to the diode bridge 103 remains unchanged. Conversely, if the resistance value of the heater 112 increases, the voltage

5 applied to the heater 112 rises. Accordingly, even if the resistance value of the heater 112 has dispersion due to the lots, the electric power supplied to the heater 112 can be stabilized. Further, as a matter of course, as the slow-up

10 sequence is conducted, the rush current at the ON-time of the heater 112 can be restrained low. Moreover, in the first embodiment, the AC current is converted into the voltage level by use of the current transformer for detecting the current, and

15 hence the AC current can be detected at a high accuracy with a less loss of the detection.
(Second Embodiment)

According to the first embodiment, even when the resistance value of the heater 112 is dispersed

20 to some extent, the electric power supplied to the heater 112 can be stabilized to the predetermined value. If the voltage of the AC power supply to be inputted changes, however, the electric power supplied to the heater 112 changes as the voltage

25 changes.

A contrivance in a second embodiment is to improve this point. A difference of the second

embodiment from the first embodiment is only the
control processing executed by the micro-controller,
and therefore the hardware components in the first
embodiment will be employed as they are.

5   FIG. 10 is a flowchart showing procedures of a
main routine executed by the MC 401 in the second
embodiment. FIG. 11 is a flowchart showing detailed
procedures of a heater resistance value measurement
processing subroutine in step S36 of the main routine.
10 FIG. 12 is a flowchart showing in-depth procedures of
a heater voltage adjustment processing subroutine in
step S39 of the main routine.

The heater drive circuit in the second
embodiment is characterized by newly providing
15 resistance value measurement processing of the heater
112. The resistance value measurement processing is
normally executed when shipping, from a factory, the
heater drive circuit or a control apparatus such as a
electrophotographic printer including the heater
20 drive circuit. The resistance value measurement
processing is not executed in a normal use by the
user.

As shown in FIG. 10, it is judged in step S34
whether the resistance value measurement processing
25 is executed or not. Namely, after switching the
power supply ON, the resistance value measurement
processing is carried out by judging a level of the

FDRVO signal in step S34 immediately after the power
supply initialization processing in steps S31 to S33.
The processing in steps S31-S33 just after the power-
ON is the same as the processing in steps S1-S3 in
5   the first embodiment discussed above. In the case of
judging that the FDRVO signal is "TRUE" just after
the power-ON, the MC 401 moves to step S36, wherein
the heater resistance value measurement processing
shown in FIG. 11 is executed. In the case of judging
10   that the FDRVO signal is "FALSE" just after the
power-ON, the MC 401 waits for predetermined time T3
in step S35 while executing nothing. Then, the MC
401 moves to the heater drive processing in the main
routine. In step S37, the MC 401 again monitors the
15   FDRVO signal and waits till the FDRVO signal becomes
"TRUE". Even in the case of executing the heater
resistance value measurement processing in step S36,
the MC 401 moves to step S37 after finishing the
heater resistance value measurement processing, and
20   waits till the FDRVO signal becomes "TRUE".

In the heater resistance value measurement
processing, to start with, in step S51 in FIG. 11,
the MC 401 resets an internal counter 2 to "0",
subsequently reads a value of the data DIDATA (0…7),
25   and judges whether or not the value of the data
DIDATA (0…7) is equal to or larger or smaller than
the predetermined value DTGT (steps S52, S53). If

DIDATA (0...7) = DTGT, the MC 401 moves to step S56 in a way that executes nothing. If DIDATA (0...7) > DTGT, the MC 401 moves to step S54 and decrements the value of the data PWMDATA (0...7) by 1. If DIDATA (0...7) <

5   DTGT, the MC 401 moves to step S55, wherein the MC 401 increments the value of the data PWMDATA (0...7) by 1. Then, the MC 401 moves to step S56 and waits for only the predetermined time T2. Subsequently, the MC 401 moves to step S57, wherein the MC 401 increments

10 a value of the counter 2 by 1, and moves further to S58. In step S58, the MC 401 judges whether the value of the counter 2 becomes equal to the predetermined value TMAX. If the counter 2 ≠ TMAX, the MC 401 moves back to S52. When the processing in

15 these steps S52 to S58 is repeatedly executed, feedback processing that follows is to be executed. Namely, the initial value of the data PWMDATA (0...7) is "0", and hence the current does not flow to the heater 112 for the first time, and the value of the

20 data DIDATA (0...7) is, as a matter of course, smaller than the value DTGT. Then, the value of the PWMDATA (0...7) is incremented till the value of the data DIDATA (0...7) reaches the value DTGT. Thereafter, the data PWMDATA (0...7) is incremented and decremented so

25 that the value of the data DIDATA (0...7) gets approximate to the value DTGT. Then, when the value of the counter 2 reaches the predetermined value TMAX

(which corresponds to the wait for the predetermined time), the increment/decrement process is stopped. The value of the data DIDATA (0...7) is thereby converged at a value substantially equal to the value

5   DTGT. If the voltage inputted to the heater drive circuit, i.e., the voltage of the AC power supply 101 is fixed to a predetermined value (in this case, it is desirable that the voltage be set to a standard value of the commercial AC power supply), the AC

10 current likewise converges at the predetermined value, and it is therefore concluded that the electric power inputted to the heater drive circuit is fixed to the predetermined value. On the other hand, a loss of the electric power due to the switching loss of the

15 FET 108 is not so dispersed, and consequently it follows that the electric power supplied to the heater in the heater resistance value measurement processing converges at a predetermined value. Accordingly, as far as the voltage of the AC power

20 supply 101 is fixed to the predetermined value, even if the resistance value of the heater 112 has the dispersion, it follows that the electric power supplied to the heater 112 converges at the fixed value.

25   Then, the MC 401 moves to step S59 and measures a value of the data DVDATA (0...7) at that time. The value of the data DVDATA (0...7) is a value

proportional to the peak value of the voltage applied in fact to the heater 112, and hence a heater resistance value can be presumed from the thus measured data DVDATA (0...7) in the following formula.

5   Heater resistance value = K × DVDATA $(0...15)^2$ where K is the fixed value.

Then, the MC 401 moves to step S60, and determines a heater voltage reference value DVREF for determining the electric power supplied to the heater 112. The value DVREF may be equalized to the value of the data DVDATA (0...15) obtained when measured. Further, the value DVREF is stored in the EEPROM 401d provided within the MC 401. Namely, even if the power supply is switched OFF, the value DVREF is kept unerasable as it is stored on the nonvolatile memory.

Then, the MC 401 terminates the heater resistance value measurement processing by cutting off the electric power supplied to the heater 112, and moves to step S37 in the main routine. The MC 401 monitors in step S37 whether the FDRVO signal becomes "TRUE" or not, and waits till this signal becomes "TRUE". Herein, the MC 401 waits for the FDRVO signal, and waits and sees whether the normal heater drive processing is executed or not. When the FDRVO signal becomes "TRUE", the MC 401 moves to step S38, and executes the slow-up sequence. This slow-up sequence is the same as the processing in steps S5-

S10 in the first embodiment discussed above. That is, the heater 112 is gradually heated up by slowly increasing the value of the data PWMDATA (0…7), thereby preventing the rush current from flowing to

5 the heater 112.

Note that the reason why the heater resistance value measurement processing in FIG. 11 has none of a particular description of the slow-up sequence, is that this heater resistance value measurement process

10 is not performed on the user's side. Accordingly, in the heater resistance value measurement processing, there is not problem if the heater 112 is started up comparatively fast, and there is no necessity of being aware of a flicker caused by the rush current

15 of the heater 112.

Then, the MC 401, after finishing the slow-up sequence, moves to step S39, wherein the MC 401 executes voltage adjustment processing. The voltage adjustment processing is repeatedly executed till the

20 FDRVO signal becomes "FALSE" in step S40. If the FDRVO signal becomes "FALSE", the MC 401 halts the execution of the processing in step S39, and executes post-processing in steps S41-S43. Herein, the MC 401 resets the internal counter 1 and the data PWMDATA

25 (0…7) to "0", and sets the RST signal to "TRUE". The drive of the FET 108 is thereby set OFF.

Now, for the duration of "TRUE" of the FDRVO

signal in step S40, the voltage adjustment
processing in step S39 is repeatedly executed. This
voltage adjustment processing will be explained in
accordance with the heater voltage adjustment
5   processing shown in FIG. 12.

At first, in step S71, a value of the data
DVDATA (0...7) is measured,

Next, the MC 401 judges whether the value of
the data DVDATA (0...7) is equal to or larger or
10 smaller than the value DVREF stored on the EEPROM
401d (steps S72, S73). If the DVDATA (0...7) = DVREF,
the MC 401 moves to step S76 while executing nothing.
If the DVDATA (0...7) > DVREF, the MC 401 moves to step
S74 and decrements the value of the data PWMDATA
15 (0...7) by 1. If the DVDATA (0...7) < DVREF, the MC 401
moves to step S74 and increments the value of the
data PWMDATA (0...7) by 1.

In step S76, the MC 401, after waiting for only
the predetermined time T2, terminates the heater
20 voltage adjustment processing.

As this processing is repeated, the value of
the data DVDATA (0...7) converges so as to be
substantially equal to the value DVREF. Judging from
the result, the value of the data DVDATA (0...7)
25 becomes the value DVREF in the same way as when
executing the heater resistance value measurement
processing. What is herein important is that even if

the voltage of the AC power supply 101 slightly
fluctuates in the midst of the heater voltage
adjustment processing, the voltage applied to the
heater 112 becomes equal to the heater voltage set in
5   the heater resistance value adjustment processing.
This implies that even when the voltage of the AC
power supply 101 fluctuates, the electric power
supplied to the heater 112 comes to the fixed value
and remains stable. Namely, once the heater
10   resistance value measurement processing is executed
in the factory, the electric power applied to the
heater 112 thereafter remains unchanged even if the
AC input voltage fluctuates.

Thus, according to the second embodiment, the
15   electric power supplied t the heater can be
stabilized to the predetermined value even when there
are the lot dispersion in the heater resistance value
and besides the dispersion in the AC input voltage.

Note that the object of the present invention
20   is, as a matter of course, accomplished by supplying
the system or the apparatus with a storage medium
stored with software program codes for actualizing
the functions in the respective embodiments discussed
above, and making a computer (or a CPU and a MPU) of
25   the system or the apparatus read and execute the
program codes stored on the storage medium.

In this case, the program codes themselves read

from the storage medium actualize the novel functions
of the present invention, and the storage medium
stored with the program codes constitutes the present
invention.

5   The storage medium for supplying the program
codes can involve the use of, for example, a flexible
disk, a hard disk, a magneto-optical disk, a CD-ROM,
a CD-R, a CD-RW, a DVD-ROM, a DVD-RAM, a DVD-RW,
DVD+RW, a magnetic tape, a nonvolatile memory card,
10   and a ROM. Moreover, the program codes may also be
supplied from a server computer via communication
networks.

Furthermore, the functions according to the
embodiments discussed above are actualized by the
15   computer executing the readout program codes, and
besides the present invention, as a matter of course,
includes a case where an OS (operating system) or the
like working on the computer performs a part or
entire processes in accordance with instructions of
20   the program codes and actualizes the functions
according to the embodiments discussed above.

Furthermore, as a matter of course, the present
invention also includes a case where, after the
program codes read from the storage medium have been
25   written in a function extension board inserted into
the computer or in a memory provided in a function
extension unit connected to the computer, a CPU or

the like provided in the function extension board or

the function extension unit performs a part or entire

process in accordance with the instructions of the

program codes and actualizes the functions of the

5   embodiments discussed above.